MAPPING TURBIDITES IN LAKE MEAD FROM SOURCE TO SINK

David Twichell[1], VeeAnn Cross[1], Mark Rudin[2],
[1] U.S. Geological Survey, Woods Hole, MA 02543
[2]Lake Mead/Mohave Research Institute, University of Nevada Las Vegas, Las Vegas, NV 89154

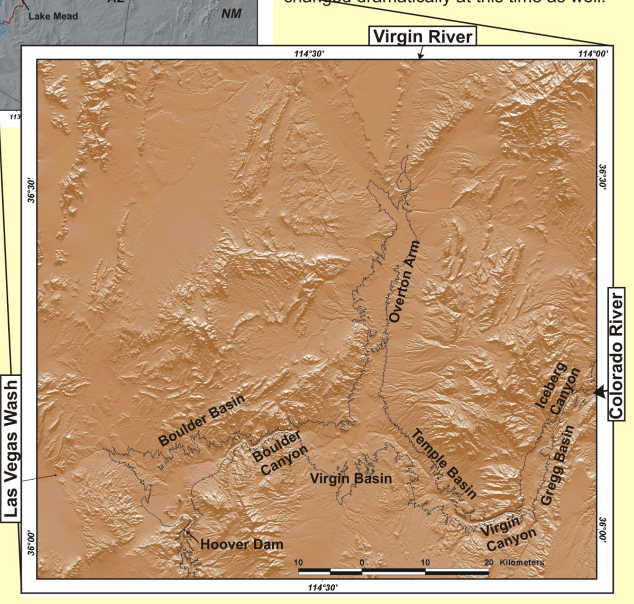
Presented at the AAPG/SEPM meeting, 2002

ABSTRACT

Lake Mead provides a unique modern analog for studying the response of a complete turbidite system to known external forcing conditions. Although density flows have been observed in the lake since completion of the Hoover Dam in 1935 the deposits resulting from these flows had not been investigated. We mapped the surficial geology and architecture of these lake-floor deposits using sidescan sonar and high-resolution seismic data. The lake is divided into five basins separated by narrow canyons. A delta fills the easternmost basin at the mouth of the Colorado River, but the existence of gas in the sediment precludes measuring the delta's thickness and internal structure. The western four basins are floored by as much as 40 m of post-impoundment sediment that fills only the deepest parts of the basins. Multiple packages of flat-lying reflectors separated by acoustically transparent zones and a flat surface characterize this fill. Reflector amplitude within individual basins is highest under the inferred axis of density flows and is weaker along the basin margins. High-amplitude reflectors observed in the subsurface of the western three basins presently are buried by mud, and only the basin most proximal to the delta has a sandy floor that is channeled. High-amplitude subsurface reflectors in the western basins suggest sand was transported farther west, but recently has been restricted to the eastern basin. Reduced river discharge since construction of the Glen Canyon Dam (1965) upstream of Lake Mead may be the cause of the sourceward shift of sand deposition.

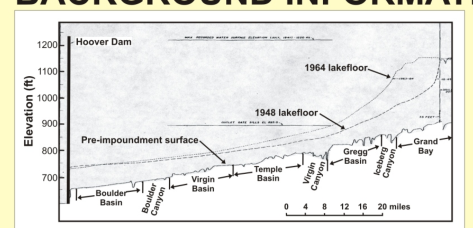
LOCATION MAP

Lake Mead is located on the eastern edge of the Mojave Desert. It formed in 1935 upon completion of the Hoover Dam The Colorado River is the primary source of water to the lake (98%), the Virgin River accounts for less than 2%, and ephemeral streams such as Las Vegas Wash account for less than 1% of the water supplied to the lake. Water input to the lake changed in 1965 upon completion of the Glen Canyon Dam and the formation of Lake Powell. Presumably sedimentation in Lake Mead changed dramatically at this time as well.

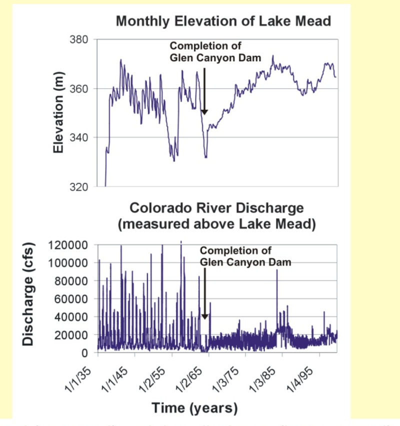


Lake Mead is divided into several basins that are separated by narrow canyons. The major basins influenced by sediment from the Colorado River include Gregg Basin (nearest the sediment source), Temple Basin, Virgin Basin, and Boulder Basin (farthest from the source). Gregg and Temple Basins are separated by Virgin Canyon, which for much of its length is less than 400 m wide. Virgin and Boulder Basins are separated by Boulder Canyon which also is less than 400 m wide.

BACKGROUND INFORMATION

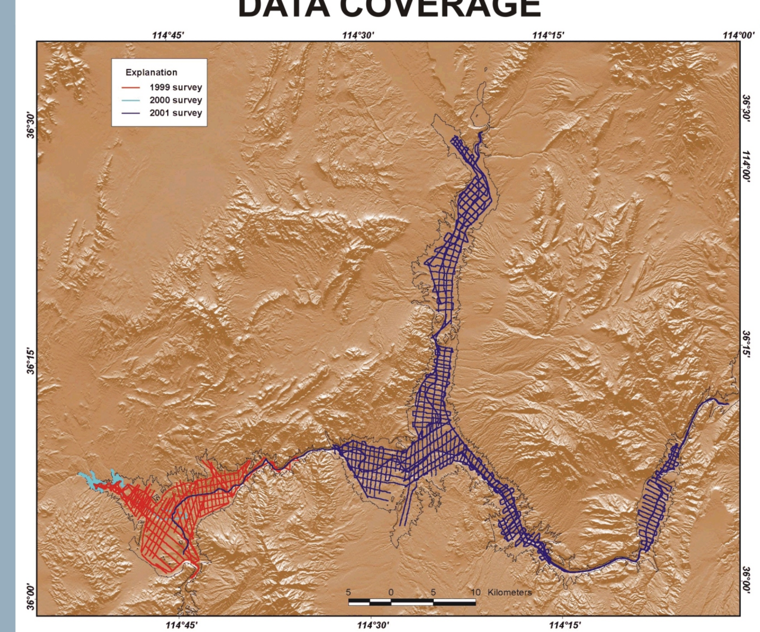


Changes in lake floor depth along the thalweg of the original Colorado River from bathymetric surveys conducted by the US Bureau of Reclamation. The pre-impoundment surface is the original grade of the Colorado River prior to construction of the Hoover Dam. The survey in 1948 shows the encroachment of the Colorado River delta into Grand Bay, and a lense of sediment covering the entire length of the lake from the delta front to the dam (approximately 70 miles). Sediment deposited prior to 1948 is thicker near the dam and thinnest in the Virgin Canyon area. The 1964 survey shows that the delta front had advanced to near the entrance to Iceberg Canyon (approximately 8 miles). Beyond the delta, the sediment progressively thins to the dam.



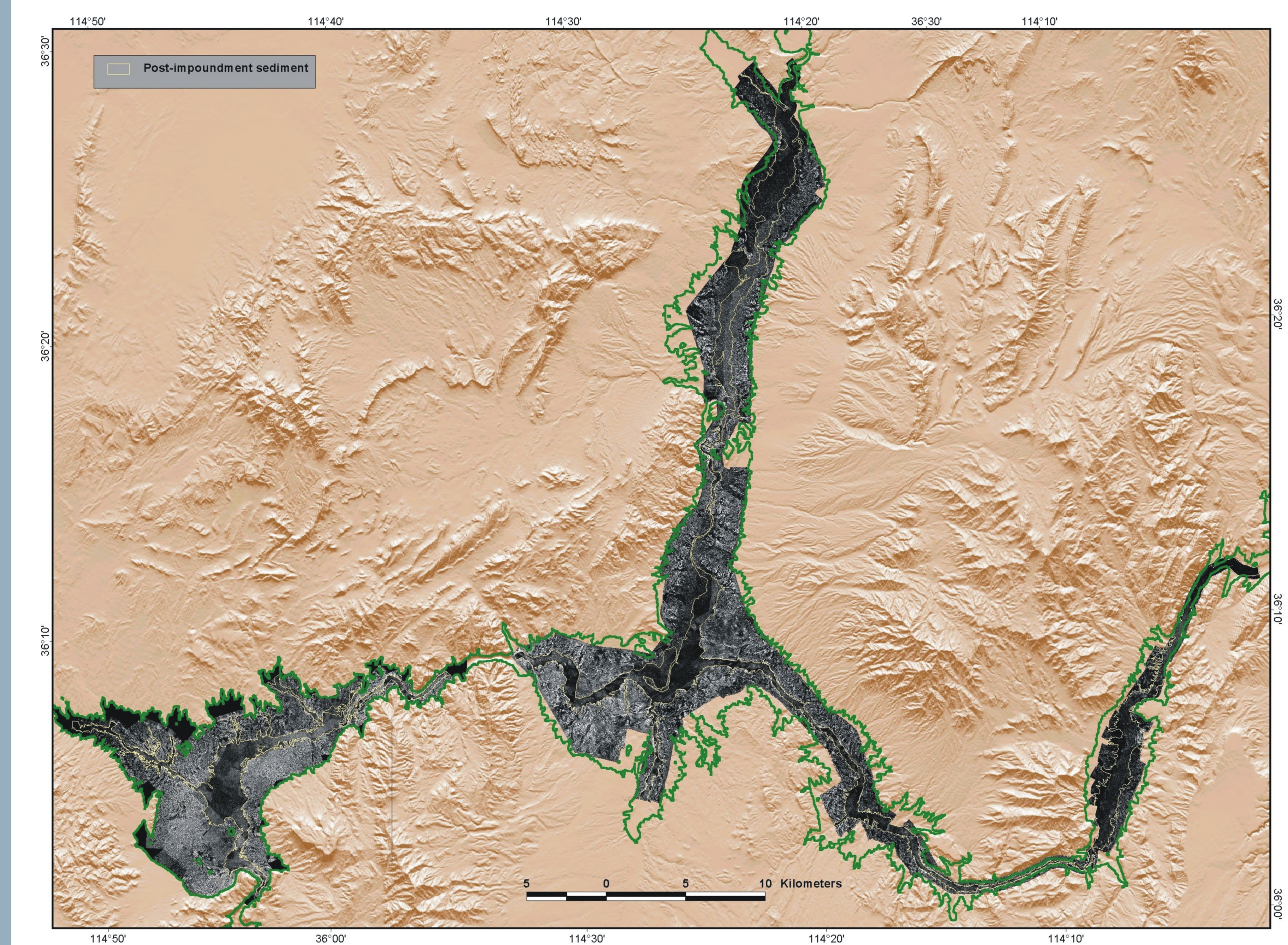
Lake level (top panel) and river discharge (bottom panel) presumably are two important controls on sedimentation in Lake Mead. Monthly measurements of lake level and daily measurements of discharge are available for the entire history of this lake. Note the dramatic change in lake elevation and discharge before and after completion of the Glen Canyon Dam and the formation of Lake Powell.

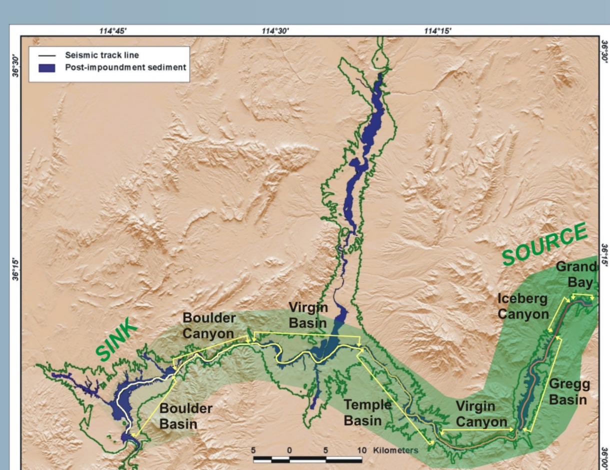
DATA COVERAGE



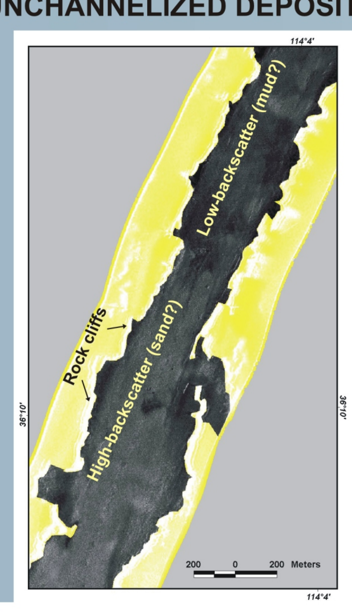
Geophysical mapping of Lake Mead was completed over a three-year period. Sidescan sonar imagery and chirp subbottom profiles were collected simultaneously along most of the track lines. Tracks were mostly spaced 500-800 m apart.

SIDESCAN SONAR IMAGERY AND POST-IMPOUNDMENT SEDIMENT DISTRIBUTION IN LAKE MEAD



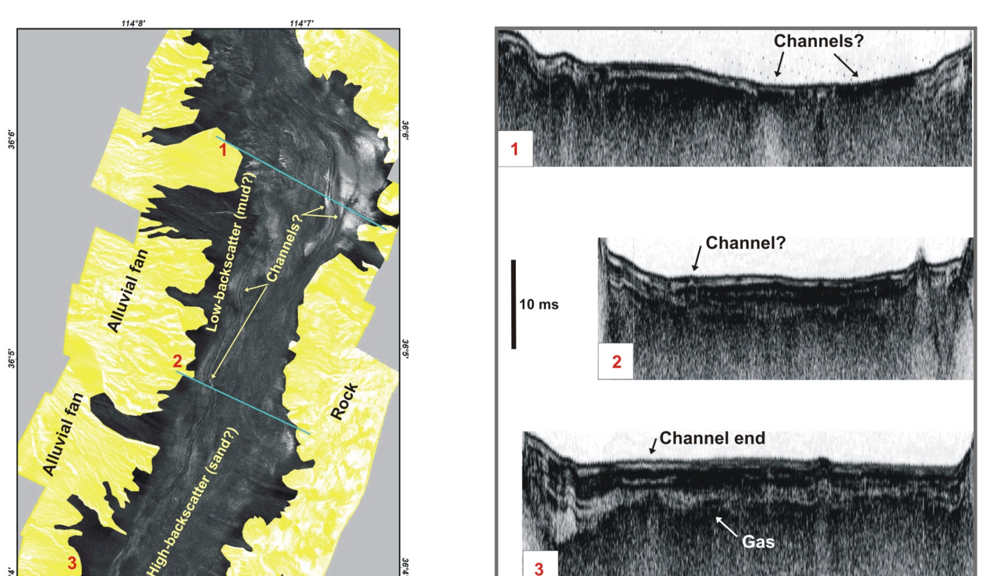


ICEBERG CANYON UNCHANNELIZED DEPOSITS



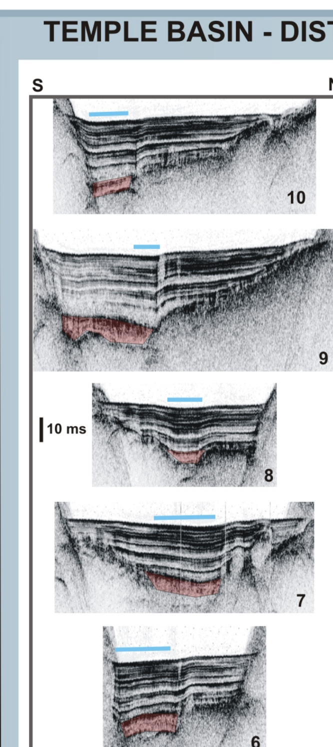
Sidescan sonar image of the steep delta front in Iceberg Canyon. Extent of the post-impoundment sediment is shown in grey shades while areas not covered by post-impoundment sediment are shown in yellow. The low-backscatter sediment (dark grey shades) in the northeastern part of the image (upslope) presumably is mud while higher-backscatter (coarser) material is exposed on the lake floor farther downslope. Note that there are no channels on this part of the lake floor while channels have developed farther downslope in Gregg Basin.

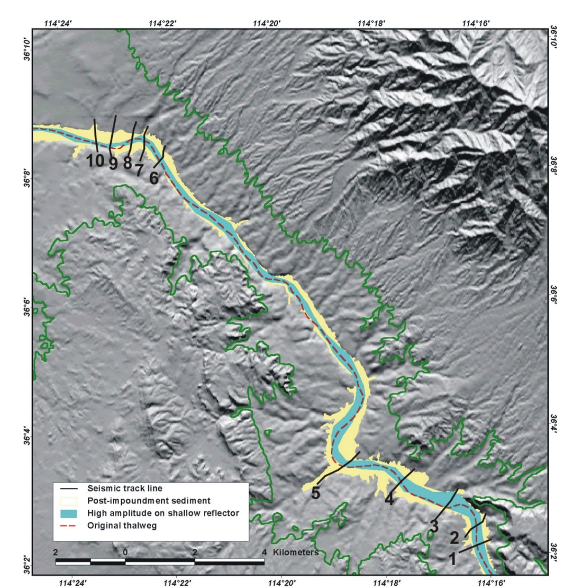
GREGG BASIN NARROW CHANNELS FLANKED BY HIGH-BACKSCATTER (SAND?) CHANNEL-LEVEE COMPLEX?



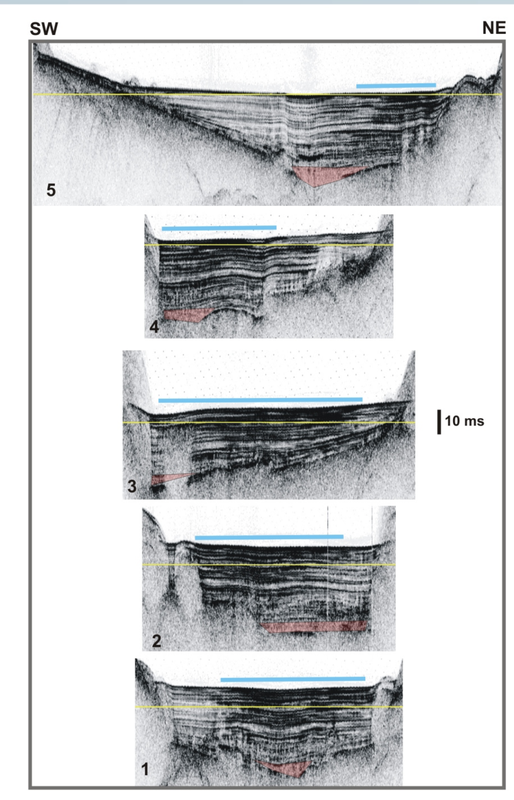
Sidescan sonar image (left panel) and Chirp seismic profiles (right panel) of Gregg Basin. On the sidescan image, the extent of post-impoundment sediment is shown in grey shades while areas not covered by post-impoundment sediment are colored yellow. Low-backscatter sediment along the flanks of the basin is interpreted to be mud while the high-backscatter central part of the basin floor is interpreted to be sand. Several channels are present in this basin, however they cannot be traced upslope to Iceberg Canyon. The Chirp profiles show almost no subbottom penetration because of gas in the sediment, and the inferred channels have virtually no bathymetric expression.

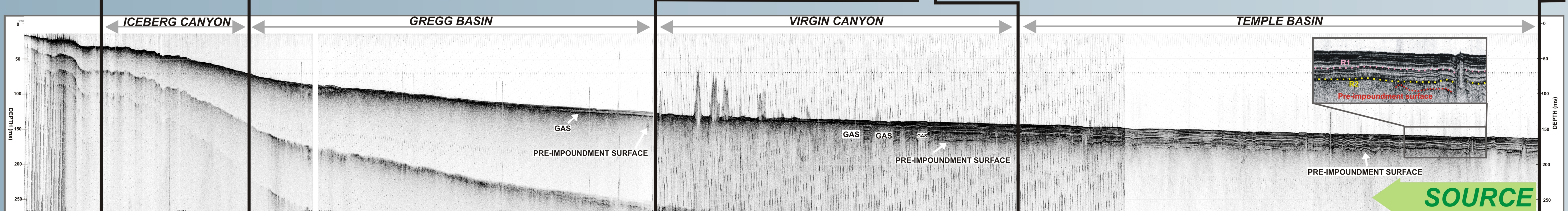
TEMPLE BASIN - DISTRIBUTION OF HIGH-AMPLITUDE REFLECTORS (SAND?) IN A SINUOUS BASIN



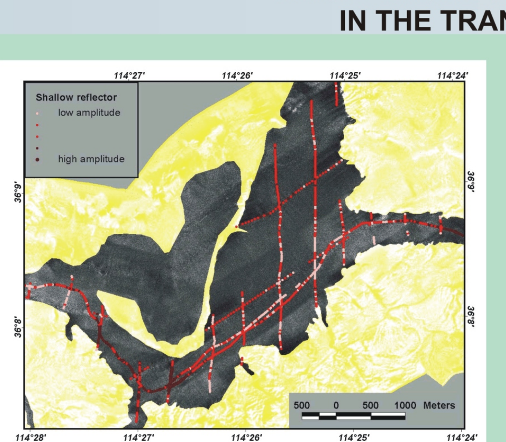


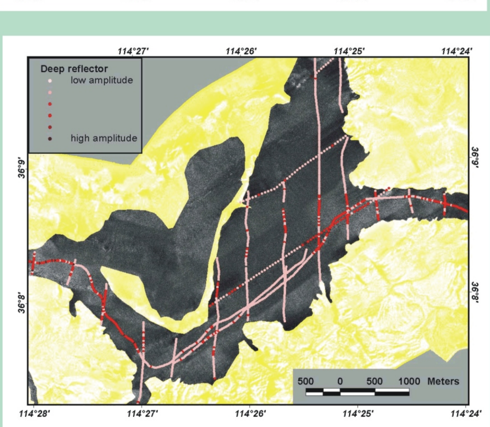
Map showing the distribution of the post-impoundment sediment in the narrow Temple Basin, the extent of the high-amplitude portion of the shallowest reflector, and the original thalweg location. The profiles show multiple reflectors within the post-impoundment sediment, and also show how reflector strength varies laterally as well as vertically. The extent of the original thalweg is shown on the profiles in red, and the extent of the high-amplitude component of the shallowest reflector is shown by the light blue line.



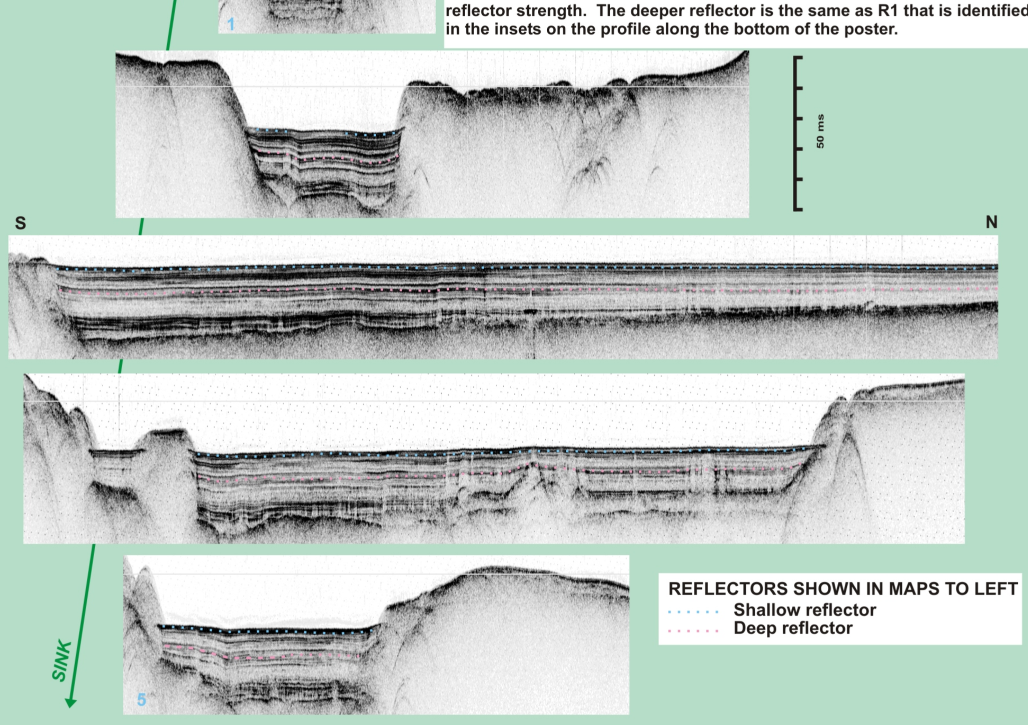


VIRGIN BASIN: DISTRIBUTION OF HIGH-AMPLITUDE REFLECTORS (SAND?) IN THE TRANSITION FROM A NARROW CHANNEL TO OPEN BASIN



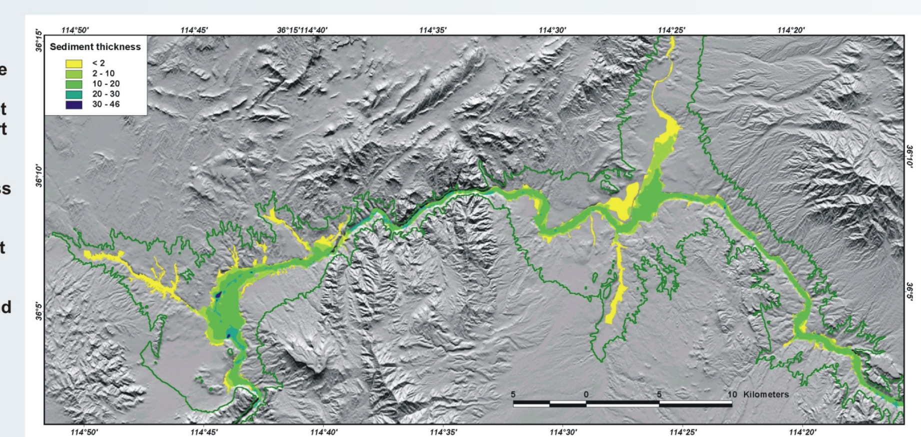


Seismic profiles and two maps showing the variation in reflector strength in Virgin Basin. The profiles show nearly continuous high-amplitude reflectors across the narrow channel east (sourceward) of Virgin Basin. In the basin, the deeper reflector is strongest in the central part and weaker to the north and south. By contrast, the high amplitude component of the shallow reflector has a much broader distribution in the basin. Cores are needed to determine the causes of the variations in reflector strength. The deeper reflector is the same as R1 that is identified in the insets on the profile along the bottom of the poster.

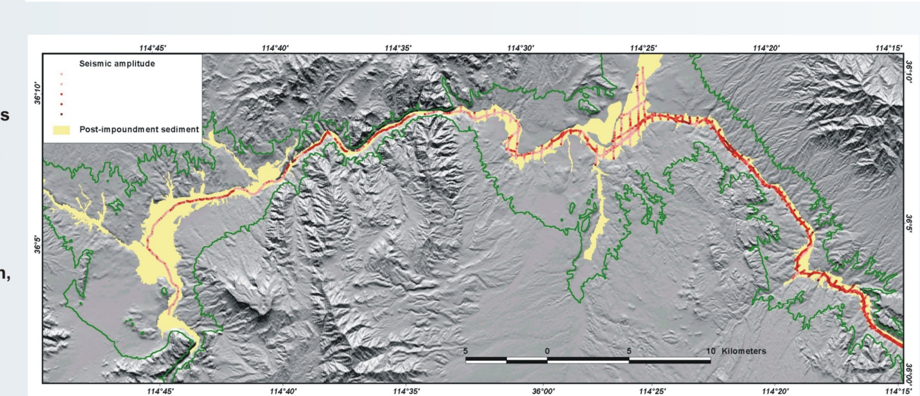


SUMMARY MAPS OF SEDIMENT THICKNESS AND STRENGTH OF REFLECTOR R1

Isopach map of post-impoundment sediment in the western part of lake Mead. Sediment thickness could not be mapped in the eastern part of the lake because of gas. Sediment is focussed in the original river valleys. It is less than 5 m thick in all valleys except in the original Colorado River valley. Here it reaches maximum thicknesses of 10-20 m in Temple and Virgin Basins, and becomes progressively thicker to the west where it locally exceeds 40 m in Boulder Basin.



Map showing the strength of reflector R1 throughout the western part of the lake. R1 is the shallowest reflector identified in the insets on the profile along the thalweg (below). This reflector is strongest nearest the source in Temple Basin, progressively decreases in strength through Virgin Basin, but then increases again in Boulder Canyon before decreasing in Boulder Basin.



SUMMARY OF KEY POINTS

- **Post-impoundment sediment appears to be deposited as turbidites -** Sediment is limited to only the deepest parts of the lake where it is flat-lying, there is no evidence of sediment drape on the walls of the lake, and the flat nature of reflectors within the deposit are consistent with a turbidity current origin. Cores will be collected later this spring to document the lithology of these deposits.
- **Sediment, where it is free of gas, becomes thicker to the west -** The isopach map to the upper left shows that post-impoundment sediment reaches a maximum thickness of 20-25 m in Temple and Virgin Basins while it reaches 40-45 m in Boulder Basin. Although subtle, these deposits are reducing the gradient of the lake floor through time.
- **Reflectors are nearly continuous throughout the lake and show dramatic changes in reflector strength -** The map to the lower left indicates that the strength of this reflector, in general, decreases away from the source area. More specifically though, reflector strength decreases westward in Virgin Basin, but then increases along the confined floor of Boulder Canyon before decreasing again where this canyon opens into the broader Boulder Basin. Cores obviously are needed to determine the causes of the variations in reflector strength, and we plan to collect cores later this spring.
- **Vertical shifts in the distribution of high-amplitude reflectors suggest changes in turbidite character with time -** In Temple and Virgin Basins, the high-amplitude portions of each reflector do not mimic what is seen on deeper horizons. Assuming the reflector strength is controlled by the nature of the deposits, the vertical changes may record changes in turbidity current sedimentation through time.
- **Channels, if present, are subtle -** The sidescan imagery in Gregg Basin suggests the presence of surface or near-surface channels, however they are not clearly shown on the seismic profiles that cross these features. Further west, there is no evidence of channels preserved on the lake floor nor in the subsurface.